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THERMAL AND MECHANICS RESEARCH IN THE USSR
R. GOULARD, DIRECTOR, JET PROPULSION CENTER, PURDUE UNIVERSITY, LAFAYETTE, INDIANA
18 February 1970

UNITED STATES OF AMERICA

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THERMAL AND MECHANICS RESEARCH
IN THE USSR

By

R. Goulard, Purdue University

Introduction

Following an invitation by Dr. O. M. Belotserkovskii, a visit to the Soviet Union was arranged to attend the Second International Colloquium on Gas Dynamics of Explosions and Reactive Systems. It included two sessions, numerical methods and general Congress, both held at Akademgorodok near Novosibirsk, 18-29 August, 1969. The week following the Congress was spent in Moscow where three Institutes were visited: the Mechanics Institute of Moscow State University (Dr. Chernyi), the Academy of Sciences Computer Center (Dr. Belotserkovskii) and the Academy of Sciences High Temperatures Institute (Dr. **Sheindlin**).

As it turned out, a number of Soviet contributors in the field of radiation energy transfer attended one or the other sessions of the Novosibirsk meeting so that an unique opportunity developed to attempt a review of their recent work. Thus, the greatest part of my time in both Novosibirsk and Moscow was engaged in private conversations with Soviet workers on the subject of Radiation Gas Dynamics. Accordingly, this report is divided in three parts:

1. An account of the visits to the Hydrodynamics Institute and to the Theoretical and Applied Mechanics Institute in Akademgorodok. Also covered are my visits to the Mechanics Institute of Moscow State University and to the Academy of Sciences High Temperatures Institute in Moscow. Not included in this part are radiation transfer studies, to be covered in the next part.

2. A report on recent Soviet work in reentry Radiation Gas Dynamics, as described by my hosts.

3. General comments on the trip.

I. Visits to Several Research Institutes

A. THE NOVOSIBIRSK SCIENTIFIC CENTER OF THE SIBERIAN BRANCH OF THE ACADEMY OF SCIENCES OF THE USSR

A visit to the following two institutes took place on the third morning of the Colloquium (August 27). Later in the day, several demonstrations of the use of explosives were performed on an isolated testing ground on the shores of the Ob sea, about two hours away from Akademgorodok by boat.*

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* See also S. C. Traugott's comments on the Novosibirsk visits (Ref.15).

1. Hydrodynamics Institute

We were first taken by bus to this Institute and were given an introduction to their work by Academician Lavrentiev, who is the originator of the whole Akademgorodok effort at Novosibirsk. A short film was shown: it presented a striking visualization of flows inside cavities at the boundaries of streams, of the formation of vortex rings in the atmosphere following explosions, etc... Lavrentiev discussed and illustrated on the board some of his ideas about the analysis of explosion effects in solid media by incompressible flow methods. We were then divided in three groups and visited in turn:

a) a ballistic impact laboratory
b) a blast welding laboratory
c) a plasma laboratory

All three specialties are not in my area of competence, and I can only repeat the reaction of several visitors, who expressed their amazement that apparently good results could be obtained from such primitive instrumentation and equipment. In my group, the most informed US observer seemed to be Dr. R. Flagg, Power Dynetics, San Leandro, California.

The activities of the Institute are described in a brochure (Ref. 1). The well-known "impulse water gun" is mentioned there as well as some work on unsteady gas turbine flows. Unfortunately, neither of these activities was discussed on this visit.

2. Theoretical and Applied Mechanics Institute

We were received at this Institute by Dr. V. V. Struminsky who gave us a rundown of the Institute's areas of interest. They seem to be rather universal, covering all areas of aerodynamics and gas dynamics from low velocity to high Mach numbers and including such aspects as combustion and low densities. More specifically, we were taken through three wind tunnel laboratories:

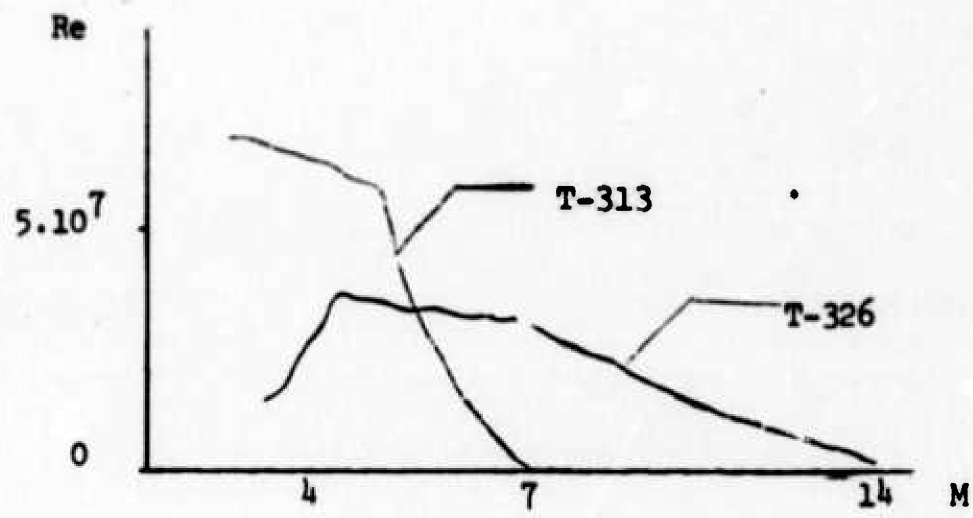
a) A supersonic blowdown wind tunnel (T-313) with provisions for heating the stagnation gas to 800°C, a Reynolds number range from 7.10^6 to 7.10^7 and a test section of 60 cm x 60 cm. The Mach number in air ranged from 1.4 to 4.5, with a capability of Mach 7 when heated.

b) A subsonic wind tunnel (T-324) with a capability of 100 m/sec only. They are checking it out now, and said that they would soon make flow separation studies in it. It has low turbulence characteristics.

c) A low turbulence wind tunnel (T-325) with a range $0.5<M<6.5$ and a test section of 26 cm x 26 cm. This tunnel is only one year old.

Finally, on the walls of one of the corridors we saw a number of explanatory displays of their activities and plans. It seems that a fourth tunnel is in the works.

d) A hypersonic tunnel (T-326) with a capability of Mach 14 and a maximum Reynolds number of about 4.10^7. My recollection of a rough graph comparison of the expected performance with that of T-313 was as follows:



Again, this experimental work would be better evaluated by some of the other US visitors, especially Dr. W. Vincenti, Dept. of Aeronautics and Astronautics, Stanford University, who has had considerable experience with similar equipment at NASA-Ames. I seem to recall that, in his judgement, similar equipment had been built in the US ten years ago, and that advanced military research would be unlikely to be conducted in those tunnels. Incidentally, several visitors (including Prof. M. Summerfield, J. Forrestal Center, Princeton University), took pictures of Dr. Struminsky's charts during his presentation, should more details on that presentation be desired (See also Ref. 15).

3. Trip to the Testing Ground

In the afternoon of August 27, a two hour boat ride took us to what looked like an Academy testing ground for explosive effects. Demonstrations were made of:

a) Vortex ring formation
b) Blast welding of two plates of dissimilar materials
c) Asymmetric explosive earth removal
d) Ballistic penetration of a target by a small spherical pellet.

Those were field demonstrations and were not meant as seriously controlled experiments.

B. MOSCOW INSTITUTES

After my return to Moscow, three institutes were visited, on 3, 4 and 5 September. As the Computer Center visit was actually only a meeting with several radiation transfer groups and did not include a tour of the facility, I shall describe here the other two institutes only.

1. Mechanics Institute (Moscow State University).

Professor Chernyi received me in his office and described the activity of his 60 "candidates" (PhD's) including 15 doctors (higher rank than PhD, with no equivalent in the US). Many of these research specialists also teach. Typically, Dr. Stulov mentioned later that he was supervising three theses, one post-doctoral fellow and taught one course at the University. These split appointments between research and teaching groups are quite common and do not need to be arranged within the same institution.

A number of disciplines are studied at the Mechanics Institute, some of them quite remote from classical "mechanics": combustion, for instance. In principle no engineering is studied at the University, rather it is taught in Polytechnic Schools or specialized Institutes, which depend also on ministries other than Education: The Aviation School, for instance, (20,000 engineering students), depends on the Ministry of Air.

I was shown:

a) A low turbulence wind tunnel, with a large test section (2 m x 4 m) where scale models of hills, cities and planes can be tested.

b) A shock tube facility (Dr. Losev), used extensively to measure chemical rates (Refs. 2-5). Two tubes were shown: a low-density shock tube (2 ft in diameter) and analogous to AVCO's, where air and oxygen relaxation times were measured and a smaller tube where H_2O dissociation rates were followed by Uv absorption of OH.

c) A blowdown wind tunnel with four ejectors which can produce a five minute flow at velocities up to Mach number 10. Stagnation conditions can be raised to 200 atm and 800°C. Several banks of automatic pressure readout printers were shown.

d) A plasma facility including:

an arc jet for the study of electrode materials and shapes

an arc jet for the study of heat transfer to electrodes

a MHD channel flow experiment in argon + traces of K (Ref. 6) to measure the reduction of turbulent heat transfer resulting from the application of a magnetic field

erosion studies on electrode materials

e) A water tunnel with velocities up to 15 m/sec. The test section looked like 1 ft x 4 ft. They study mostly cavitation problems but also drag reduction by polymer injection.

Chernyi also alluded briefly to a ballistic tunnel facility located in the Institute basement, where he is now conducting experiments on projectile flight through combustible gases.

The rest of the time was devoted to a discussion of their radiation program with Dr. Stulov and his group. This is reported in the second part of this report.

2. High Temperature Institute (Ak. Nauk SSSR)

I was received by the Director, Dr. Sheindlin, who was surrounded by several of his senior scientists, including L. Biberman and T. Bazhenova. Sheindlin made a very formal presentation of the Institute, translated sentence by sentence, while the others listened patiently. The organization of the Laboratory is described in much detail in Ref. 7. Dr. Sheindlin compared his activities to those of the US National Bureau of Standards in the area of high temperature, supplemented currently by a large applied effort in the area of MHD power generation.

The following laboratories were visited:

a) The Plasma Section

Measurement of A^+ radiation (excluding N_2^-)(Ref. 8)

Measurement of conductivity and radiation in plasmas

Line measurement techniques (Ref. 9)

b) The Shock Tube Group

A discussion by Dr. Kon'kov of their current shock tube studies of CN, $N_2(1-)$, N^-, CO_2 radiation. A detailed review of this area of work appeared recently (Ref. 10).

Dr. T. V. Bazhenova presented some recent results from their shock propagation studies and discussed some absorption anomalies which they cannot explain.

Near critical point heat transfer. Several studies regarding the Nusselt numbers of cooling vs heating boiling mixtures and that of dissociating N_2O_4 were discussed (Ref. 11).

Dr. Vasileva's laboratory was also visited after lunch. She makes several optical measurements on discharge gases (Ref. 12), and has also developed a seeding method for flame burners which enables a good optical scanning measurement of temperature profiles.

c) The Theoretical Group (L. Biberman)

In addition to the reentry shock layer and precursor work reported later, this group is engaged in the publication of tables of emission properties of high temperature gases. Their work on air has been published this year (Refs. 13, 14).

The quality of work shown to me at the High Temperature Institute was unusually impressive. I was also given to understand that a good part of their activity was classified.

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II. Reentry Radiation Gas Dynamics in the Soviet Union

Most of the discussions reported below had to do with studies motivated by the reentry problem. Other radiation gas dynamics applications were rarely discussed, although some calculations (such as high temperature physical properties) are obviously of a more general interest.

A number of papers have been written on this subject in recent years, especially in Teplofizika Vysokikh Temperatur and in Izvestía Ak. Nk. SSSR - Mekhanika Zhidkosti i Gaza. As no systematic English translation of the latter journal seems to be available now,* I was introduced to a surprising amount of material completely new to me. Therefore, this report is not an attempt to analyze this information and to compare it with its counterpart in the US. It is rather meant to quickly pass on comments and references recently received from our Soviet colleagues. As translation help was adequate most of the time, these statements should represent fairly accurately what my hosts meant to convey.

Recent Soviet reentry papers have often been the product of a joint effort by several of the following research groups, all located in and around Moscow (see also Table I in part III):

a) The Academy of Sciences High Temperatures Institute
b) The Academy of Sciences Computing Center
c) The Academy of Sciences Cosmic Research Institute
d) The Moscow State University Mechanics Institute
e) The Zhukovski Central Aero Hydrodynamics Institute (TsAGI)

In addition to a number of informal discussions, five official gatherings were held. The first two were radiation transfer sessions at the Novosibirsk Congress, a planned one on 23 August and an improvised one on 26 August. The other three were visits to three of the institutes listed above under d, b and a, on 3, 4 and 5 September, respectively.

*Such a regular translation has been undertaken recently by the Faraday Press, New York, under the title Fluid Mechanics. According to them, the first volume (1966) is about ready to be released and the second (1967) should follow by the middle of 1970. RG (Dec '69)

A. THE RADIATION TRANSFER SESSION AT THE NUMERICAL METHODS PART OF THE NOVOSIBIRSK CONGRESS (23 August)

Two Soviet papers on radiation transfer were presented on 23 August:

L. M. Biberman, S. Ya. Bronin and A. N. Lagarkov, "The Flow and Heating of Blunt Bodies of Reentry Conditions"

O. M. Belotserkovskii and V. N. Fomin, "Study of Supersonic Radiation Flow Past Blunted Bodies"

On that afternoon, translation was inadequate and I found it impossible to evaluate the originality of these two papers compared to the authors' earlier works. I learned later from Biberman that he planned to submit his paper to JQSRT, and Belotserkovskii indicated that his paper was basically that published earlier this year as Ref. 1.

Several discussions were held privately with participants and will be reported in the next sections.

B. THE INFORMAL RADIATION TRANSFER SESSION AT THE NOVOSIBIRSK CONGRESS (26 August)

This improvised session was organized by L. M. Biberman as a forum for the many radiation transfer specialists who happened to attend the Congress. Participating were a number of speakers: Biberman, Traugott, Vincenti, Lobb, Oliver, Gardiner, Stulov, etc.

Biberman stressed that in many cases an exact knowledge of radiation absorption properties was not available yet. He felt that atomic species were well understood but molecular ones such as N_2, O_2, N_2 were not well known in the visible and uv region.

The validity of grey gas modeling (for "two-step" models), was the topic which stirred the most response and controversy from the audience.* The chairman finally summarized the discussion as follows:

a) Grey gases can be useful for rough parametric studies.

b) No criterion exists to validate a grey gas model with any generality.

c) Radiation and non equilibrium kinetics must be treated as coupled effects in an increasing number of situations.

d) Results for 3-dimensional geometries can be substantially different from those obtained in 2-dimensional cases. They are unfortunately cumbersome to calculate.

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* At one point, Biberman sighed: "On n'enterrera jamais le gaz gris."

C. THE ACADEMY OF SCIENCES HIGH TEMPERATURE INSTITUTE, MOSCOW E-250, Ul, KRASNOKASARMENNAYA 17A

The work of Biberman's group in reentry radiation is already well known in the US because of his 1964 review in Cosmic Research (Ref. 2). A more recent paper of theirs (1967) has unfortunately escaped attention in the West (Ref. 3), probably because the journal is not available in English translation. As indicated earlier, their most recent work was presented at the first session of the Novosibirsk Congress.

The 1967 paper was the joint product of a group of physicists at the High Temperature Institute (Biberman, Vorobiev, Lagar'Kov, Yakubov) and of a group of fluid dynamicists at the Mechanics Institute-Moscow University (Stulov, Telenin, Shapiro).

It considered a non-equilibrium shock layer in air with electron temperature and ionization lags. It included continuum radiation and also 18 lines of oxygen and nitrogen ions. The velocity range was 10 to 16 km/sec and the ambient pressure 10^{-2} to 10^{-5} atm.

Although, at first reading, the 2-dimensional aspect of the finite shock layer seems to have been talked out of the problem (later studies from their group include the full geometry but not the detailed physical model), several aspects were new at the time:

a) their use of lines in energy transfer calculations. As I recall, they found it to be of the same order of magnitude as the continuum radiation.

b) their uncoupling of the precursor effect on the basis that regardless of the photoionization mechanism, it does not affect the initial electron concentrations enough to change the profiles behind the shock appreciably. In their opinion, the one precursor effect that was likely to happen was photo-dissociation of molecular oxygen ahead of the shock (Ref. 4). It was not clear from this statement whether they did not believe that electron precursors exist at all or only that they were uncoupled from the energetics of the shock wave.

c) the introduction of a "damping coefficient" to the radiative flux in the iterative solution of the conservation equations. Stulov mentioned that Chudov (Inst. of Mechanics, Ac. Science) had suggested this approach as the most appropriate to the problem. It is incidentally the same method as the one independently developed by Chapin (Ref 5).

In this scheme (Ref. 3), the initial properties of each iteration sequence at n km/sec reentry velocity for instance, were those calculated at n-1 km/sec (beginning with n = 10). It was found that while two or three iterations were sufficient at 10 km/sec, about seven were necessary at 16 km/sec (Stulov). Biberman gives the computer time for each flight case as less than one hour on a Minsk-22 machine (analogous to the BESM-2: 5000 operations/sec).

Another group of the High Temperature Institute (Dr. Kon'kov) published early this year an extensive review of the optical properties of air in reentry shock layers (Ref. 6) with several suggested closed-form approximations. Although the bulk of the experimental data illustrated in this review seems to be from US sources, their Institute has an active shock tube program in this area (see Part I).

Finally Biberman's name appears with that of Lagartov as co-authors of Ref. 7, where they probably supplied the simplified radiation model to the Computing Center group.

There was no expressed interest whatsoever in Argon precursors.

D. THE ZHUKOVSKI CENTRAL AERO HYDRODYNAMICS INSTITUTE (TsAGI)

Although this center was not visited, Zhigulev, Romishevskii and Vertushkin were able to attend and participate in the discussion organized on 4 September at the Computing Center.

Zhigulev who is well known for his early review of reentry radiation (Ref. 8), has since written some papers of more academic interest including one refinement on wall conditions (Ref. 9). As could be expected, his group appears currently to be quite involved in reentry problem studies.

Romishevskii stated that he felt that precursor ionization in air would proceed as follows:

$$O_2 + h\nu \rightarrow O_2^+ + e^-$$

followed by a recombination:

$$O_2^+ + e^- \rightarrow O + O$$

and partially by

$$M + O + O \rightarrow O_2 + M$$

In effect, his is the same argument as Biberman's in the sense that the second reaction is about as fast as the first and they practically can be lumped as:

$$O_2 + h\nu \rightarrow O + O.$$

There again, no decisive statement was made about the nature of precursors.

Perhaps because of this, Zhigulev stated that in his opinion, the reentry problem has become a matter of understanding the physics rather than the fluid mechanics of the problem. He was evasive as to his other activities.

I was also presented, without discussion, with a reprint of Vertushkin's Ref. 10.

E. THE ACADEMY OF SCIENCES COSMIC RESEARCH INSTITUTE

Neyland, also well known for his reentry performance analyses (Ref. 11), came to the 4 September meeting at the Computer Center. He has also made studies of radiation boundary layer coupling (Ref. 12) and inviscid radiating flows (Ref. 13).

His interests are now in the field of massive ablation (presumably radiation driven). He suggested a model dividing the shock layer into three parts: one inviscid layer near the shock, another inviscid layer near the wall with strong gas injection v_w, and a viscous floating layer in between, calculated by asymptotic expansion. He felt that the inviscid wall layer model was acceptable as long as $v_w \gg \frac{1}{\sqrt{Re}}$

Tirskii (Moscow University Mechanics Institute) disagreed with this and stressed the need for wall shear flow to establish the proper ablation rate.

Zhigulev mentioned that he is interested in a similar problem but with much larger optical thicknesses. No interest was shown for unsteady solutions.

Neyland also expressed curiosity in regard to the accuracy of Hoshizaki-Wilson's shock layer representation away from the stagnation point.

F. THE ACADEMY OF SCIENCES COMPUTING CENTER, MOSCOW
B-333, Ul. VAVILOVA 40

Oleg Belotserkovskii, who organized the 4 September visit, has been active himself in the above problems in recent years. He has applied his numerical methods of flow analysis to the radiating shock layer problem (Ref. 14, 7 and 1).

The papers above, written in collaboration with Fomin, considered the flow field aspect away from the stagnation point. The complete radiative flux expression was replaced by a local approximation of the Milne Eddington type.

A similar "local" simplification was used by Alexandrov (Ref. 15) in the calculation of a radiating flow through an axisymmetric nozzle. Numerical methods were developed, which include a fairly complex absorption coefficient expression, but only in terms of local properties, thereby avoiding 3-dimensional and iteration difficulties.

Alexandrov stressed that in his opinion this aspect of radiation gas dynamics (i.e., multidimensional statements of long range photon exchanges) is in much want of some serious attention. A new group (Alexandrov, Shipilin) has begun to look into these problems at the Physico Technical Institute*. (Also, V. Ya. Goldin (AC. Sci. SSSR-Applied Mathematics Institute) discussed similar moment method work at the Novosibirsk Conference).

G. THE MOSCOW STATE UNIVERSITY MECHANICS INSTITUTE,
MOSCOW B-234 MINCHURINSKII PROSPEKT 1

Dr. V. P. Stulov, who seems to be in charge of a small group of young scientists and students, cooperated with Telenin and Shapiro in the work of Biberman's group in Ref. 3. He and Shapiro have also used recently simpler models to roughly describe the shock layer in closed form (Ref. 16).

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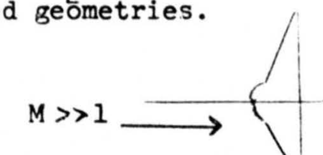
* V. V. Alexandrov, like many of his colleagues, has a joint appointment to a research position (Computer Center) and to a teaching one (Physico Technical Institute). He teaches a course of radiation gas dynamics as an elective in the 5th year of the applied mathematics option at PTI.

Current work in the group includes the low Reynolds number case $10 < Re < 10^4$ between Mach 10 and Mach 50. The effects of viscosity, radiation losses and chemical relaxation vary in relative importance throughout this (M, Re) domain.

Current plans include studies of flows in CO_2 atmospheres, down-stream of the sonic line and past complicated geometries.



A totally unimpressive presentation in ablation boundary layers was also made by G. A. Tirskii.

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III. GENERAL COMMENTS

Several impressions of general nature came out of these meetings. Because of the obvious limitations of this short visit and because of the availability of far more comprehensive studies, their generalization would be risky and unnecessary. On the other hand, these recent data points may add some details to the existing picture of Soviet Research. Before describing these impressions, I shall first sketch in part A the administrative relationship of the various groups mentioned earlier in this report.

A. RESEARCH AND EDUCATIONAL INSTITUTIONS

As Ref. 1 points out, research and development is organized in the Soviet Union under three authorities:

The Academy of Science and its provincial branches
The Ministry for Higher and Secondary Specialized Education
The Industrial Ministries and other Government Departments

All report to the government, assisted in this R & D coordination task by the State Committee for Science and Technology (Chairman V. A. Kirillin). The attached table was drawn in 1965 by V. Prokudin, now in the administrative office of the Academy of Sciences, during a visit to Purdue University. It illustrates the organizational relationship between the various research groups mentioned in this report, obviously a tiny fraction of the whole organization.

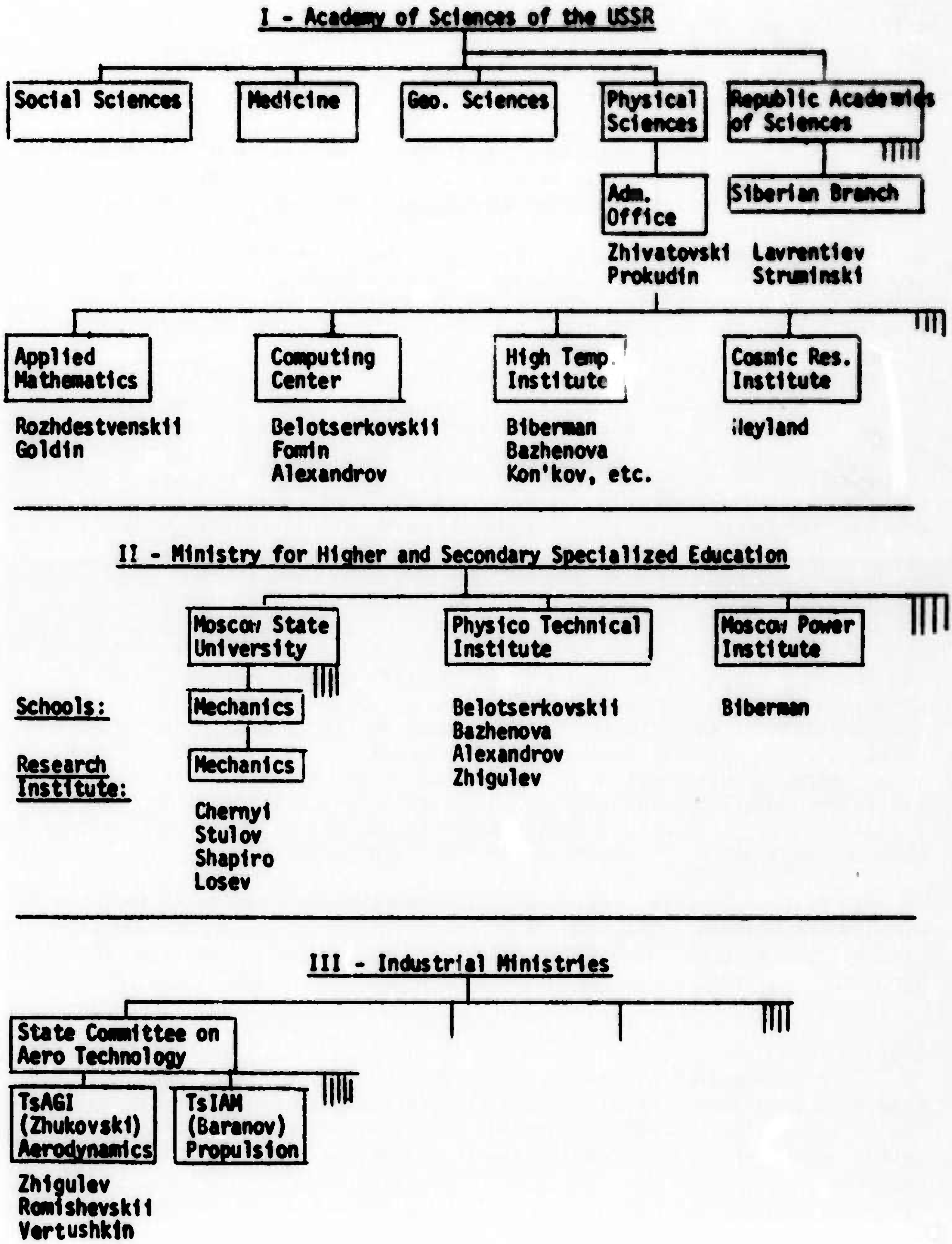
The organization of the engineering institutes was not made too clear to me at any point of the trip and it is therefore omitted from the table. Several older but detailed references are available on this subject, in particular on Aeronautics education (Trilling--Ref. 2 and 3). See also Ref. 4 for railroad communications.

B. "MULTIPLE HAT" APPOINTMENTS

I do not recall that any one of the scientists I met had less than a teaching and a research appointment, carried in two different institutions. Dr. Chernyi confirmed that the arrangement was not only common but quite flexible: University teachers do not necessarily do research in their University Institute but often at the Academy of Sciences or in one of the Industry Laboratories.

However, L. Biberman who teaches at the Moscow Power Institute (in addition to his duties as Chief of the Theoretical Department at the High Temperature Institute), indicated that, at MPI at least, the

Table I


I - Academy of Sciences of the USSR
Social Sciences
Medicine
Geo. Sciences
Physical Sciences
Republic Academies of Sciences
Adm. Office
Siberian Branch
Zhivatovski
Prokudin
Lavrentiev
Struminski
Applied Mathematics
Computing Center
High Temp. Institute
Cosmic Res. Institute
Rozhdestvenskii
Goldin
Belotserkovskii
Fomin
Alexandrov
Biberman
Bazhenova
Kon'kov, etc.
ileyland
II - Ministry for Higher and Secondary Specialized Education
Moscow State University
Physico Technical Institute
Moscow Power Institute
Schools:
Mechanics
Research Institute:
Mechanics
Chernyi
Stulov
Shapiro
Losev
Belotserkovskii
Bazhenova
Alexandrov
Zhigulev
Biberman
III - Industrial Ministries
State Committee on Aero Technology
TsAGI (Zhukovski) Aerodynamics
TsIAM (Baranov) Propulsion
Zhigulev
Romishevskii
Vertushkin

majority of the faculty does only teaching (as suggested in REf. 1, p. 23, for instance). He felt that his own "multiple hat" appointment although highly desirable for both students and his research lab, was the exception rather than the rule.

T. V. Bazhenova described the six-year curriculum of the Physico Technical Institute where she teaches (in addition to her managing the shock tube department at the High Temp. Inst.) as a specially research oriented curriculum where three-years are spent on a classical curriculum as elsewhere, but the last three are under the supervision of a major professor from an outside laboratory. Several times, in conversation with Academy administrators (Zhivatoski, Prokudin), this Institute was singled out as the place where research scientists go and lecture (e.g., Bazhenova, Zhigulev, Alexandrov).

I was impressed by the relatively large number of young scientists and of women scientists whom I saw in most laboratories I visited.

These remarks apply to research scientists only, as engineers are trained in separate schools (see part IB1) and very little work of engineering nature seems to be shown to visiting foreigners.

C. NOVOSIBIRSK'S AKADEMGORODOK

Much hope and propaganda (Ref. 5 and 6) has been centered on this new "Science City" which is now about 10 years old and counts 40,000 inhabitants. This new departure from the crowded city centers to a self-contained living and working place in the Siberian birch forest still attracts some of the original enthusiasm. Typically, the idea of a few years of quiet work away from Moscow seemed to make sense to Professor Stulov, for instance. Also attractive was the fact that the streets and public places of Akademgorodok look definitely more lively than Moscow,* perhaps because of the younger population.

However, the reflection of this momentum into the quality of the work is not obvious. The best participants at these two meetings were clearly from Moscow. Oleg Belotserkovskii expressed some reservations about the new center.

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* Moscow does not seem to have inspired any of the travelers' reports I have read. Of his recent trip to the USSR (Ref. 7), Arthur Miller says: "The streets of London, Paris, New York, Milan are in motion with people going somewhere. In Moscow, they are all on their way home."

He felt that the initially high quality of work in Novosibirsk had diluted as fast as the number and size of the institutes had increased. He also enlarged this quantity vs quality opinion to include Soviet engineering education in general. Engineering schools' enrollment has increased so fast that one can now select between only two or three candidates for one admission, while the figure was more like ten in previous times. Hence large crops of poorly gifted engineers. Meanwhile, a shortage of qualified technicians exists: why then produce an excess of second rate white collar theorists?

This "elitist" viewpoint reflects the position of the rather selective Physico Technical Institute. Of course, as world news show, this problem of mass education and of its relevance is currently shared by all modern nations.

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13. ABSTRACT

The author reports on the Second International Colloquium on Gas Dynamics of Explosions and Reactive Systems in the USSR. He also gives an account of his visit to the Hydrodynamics Institute and to the Theoretical and Applied Mechanics Institute in Akademgorodok. Also covered are his visits to the Mechanics Institute of Moscow State University and to the Academy of Sciences High Temperature Institute in Moscow, and recent Soviet work in reentry Radiation Gas Dynamics.

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